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APPRENTICESHIP TRAINING

TOOL AND DIE MAKER SKILL PROFILE

Alberta
CAREER DEVELOPMENT AND EMPLOYMENT
Apprenticeship and Trade Certification

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INTRODUCTION

The purpose of the Tool and Die Maker Skill Profile is to identify the basic skills/knowledge required by a journeyman Tool and Die Maker, with the intention of providing assitance to those individuals who qualify to write the journeyman examination. Although an apprenticeship training program is currently not available in Alberta for the Tool and Die Maker trade, terminal performance objectives are stated in the Skill Profile should industry demand increase sufficiently to warrant development of a formal training program. The questions contained in the journeyman Tool and Die Maker examination relate directly to the content stated in the Skill Profile.

The basic skills/knowledge listed in the Skill Profile have been indentified by the Provincial Apprenticeship Committee for the trade.

APPRENTICESHIP COMMITTEE STRUCTURE

Tool and Die Maker Provincial Apprenticeship Committee

The Provincial Apprenticeship Committee for the Tool and Die Maker trade is comprised of members from Local Apprenticeship Committees from the cities of Calgary and Edmonton.

This Committee is concerned with the policies that guide the program and make recommendations to the Apprenticeship and Trade Certification Board and the Executive Director of Apprenticeship and Trade Certification in the following areas:

★ Contribute current information relative to changes in the trade and requirements of industry.

★ Make recommendations for changes to existing trade regulations.

★ Assist in updating through recommendations for revisions to the Skill Profile and attendant examination(s).

Tool and Die Maker Local Apprenticeship Committee

Local Apprenticeship Committees are concerned with individuals and trade situations within a local region. Meetings are hold throughout the year to make recommendations and to discuss problems relating to the certification program.

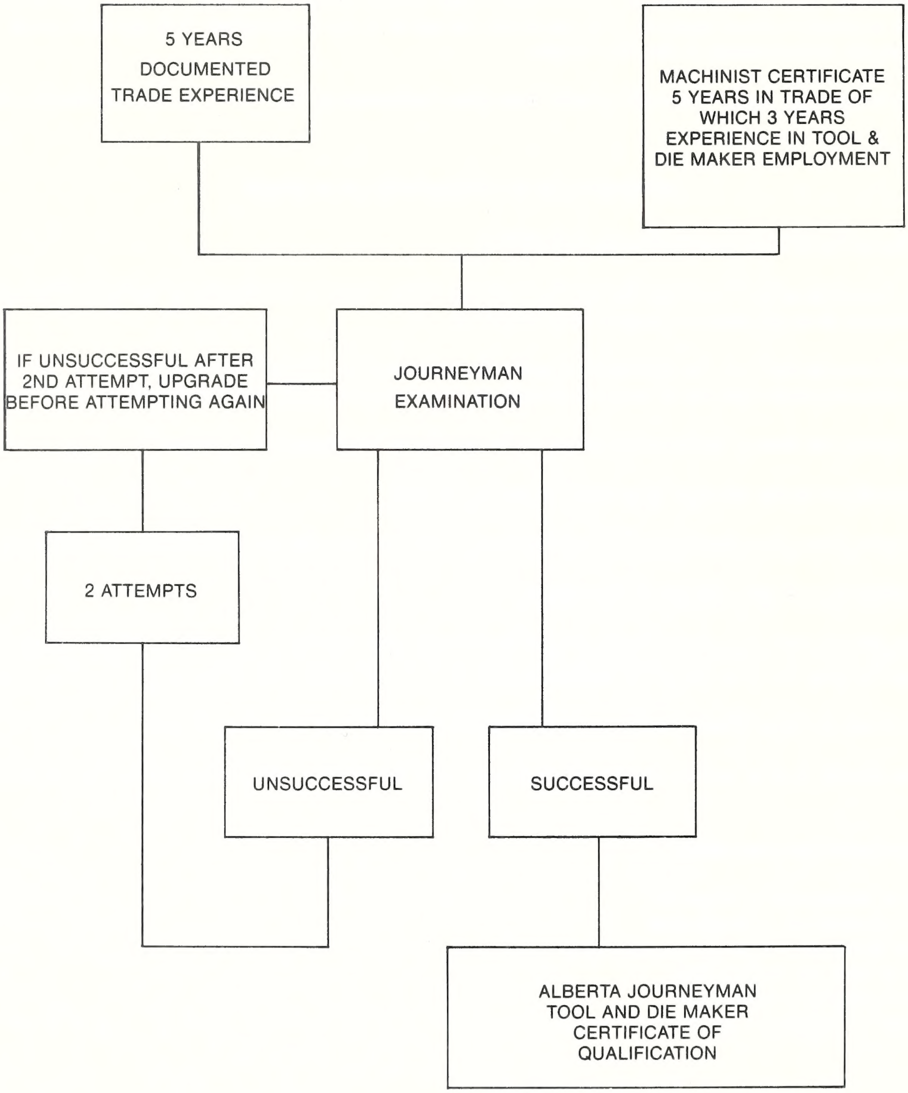
Members who serve on Committees may be nominated by employer and labour organizations.

Membership is equally divided into employer and employee representation in accordance with The Manpower Development Act.

Apprenticeship Committee Members:

Mr. H. Witzler — Edmonton — Employer
Mr. W. Sauer — Edmonton — Employee
Mr. R. Fouts — Edmonton — Employer (Alternate)
Mr. E. Sievers — Calgary — Employer
Mr. J. Purnell — Calgary — Employee
Mr. G. Bergstein — Calgary — Employee (Alternate)

TOOL AND DIE MAKER


5 YEARS DOCUMENTED TRADE EXPERIENCE
MACHINIST CERTIFICATE 5 YEARS IN TRADE OF WHICH 3 YEARS EXPERIENCE IN TOOL & DIE MAKER EMPLOYMENT
IF UNSUCCESSFUL AFTER 2ND ATTEMPT, UPGRADE BEFORE ATTEMPTING AGAIN
JOURNEYMAN EXAMINATION
2 ATTEMPTS
UNSUCCESSFUL
SUCCESSFUL
ALBERTA JOURNEYMAN TOOL AND DIE MAKER CERTIFICATE OF QUALIFICATION

TOOL AND DIE MAKER SKILL PROFILE

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BENCHWORK

TERMINAL PERFORMANCE OBJECTIVES

A. Hand Operations

1. Safety
   (a) general
2. Vises
3. Hammers
4. Metal stamps
5. Screwdrivers
6. Wrenches
7. Hacksaws and blades
8. Files
9. Abrasive cloths
10. Cold chisels
11. Punches
12. Taps
13. Dies
14. Hand reamers
15. Stud extractors
16. Broken tool extractors
17. Scrapers
18. Pliers
19. Hand broaches
20. Thread reconditioning by inserts
21. Deburring
22. Silver soldering
23. Component assembly/fitting
24. Power hand tools

1. List safety rules pertaining to bench work.
2. Demonstrate proper usage of necessary hand tools.
3. Demonstrate safe usage of power hand tools.
4. List power hand tool maintenance precautions.
5. Demonstrate hand tool maintenance procedures.
6. Demonstrate ability to assemble various types of mechanical components.

B. Layout

1. Surface plates
2. Laying out the work piece from drawings and specifications.
3. Coatings used for layout preparation.
4. Cleaning agents
5. Scribers
6. Prick punches
7. Centre punches
8. Hammers
9. Trammels
10. Dividers

1. Describe types and uses of layout tools and equipment.
2. Demonstrate ability to prepare surfaces for layout.
3. Scribe reference lines on material to conform with blueprint to conform blueprint requirements.
4. Describe proper care, maintenance and storage of layout tools and equipment.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
11. Hermaphrodite calipers	
12. Surface gauges	
13. Vernier height gauges	
14. Clamps (a) "C" (b) keyseat	
15. Templates	
16. Combination squares	
17. Straight edges	
18. Protractors	
19. Angle plates	
20. Parallels	
21. "V" blocks	
22. Sine bars	
23. Gauge blocks	

ASSEMBLY AND FITTING

A. Fasteners	
1. Threaded	1. Identify and describe types of fasteners and their applications.
2. Non threaded	2. Describe types and uses of keys and keyways.
3. Head styles	3. Demonstrate cutting and fitting keys and keyways.
4. Point styles	
5. Driving recesses	
6. Tensile and grade definitions	
7. Common types of keys and keyways	
B. Scraping	
1. Machine components	1. List purpose of scraping.
2. Bearing surfaces	2. Demonstrate scraping techniques.
C. Component Alignment	
1. Dowels (a) cylindrical (b) tapered	1. List purpose of dowels. 2. Determine type and size of dowels to be used. 3. Correctly align and assemble dowelled components.
2. Force-fitted components (a) press fit (b) interference fit	1. Identify force fitted assemblies. 2. Identify principles and limitations of force fitted assemblies. 3. Fit force fitted assemblies without causing damage to, or deformation of components.
3. Running fitted components (a) precision (b) close (c) medium (d) free (e) loose (f) lubrication	1. Identify running fitted assemblies. 2. Assemble running fitted components. 3. Identify lubrications procedures.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
4. Slide/locational fitted components (a) sliding (b) close sliding (c) locational (i) clearance (ii) transition (iii) interference	1. Identify and describe types of tapers and their applications. 2. Describe methods of taper measuring and gauging. 3. Describe methods and manufacturing tapers, including necessary calculations.
5. Tapers (a) parts (b) purposes (c) measuring and gauging (d) calculations (e) systems and applications (f) methods of producing	
6. Lubrication (a) purpose (b) types (c) charts (d) methods of application (e) locations (f) scheduling	1. Describe purpose of lubrication. 2. Describe various types of lubrication and their applications. 3. List methods of applying lubricants. 4. List reasons for lubrication scheduling.

GENERAL MACHINE OPERATIONS

A. Drilling and Allied Work

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
1. Safety 2. Types of drilling machines (a) senstive drill (b) pedestal drill (c) radial arm drill 3. Tool holding devices (a) chucks (b) taper sleeves (c) sockets (d) tap holders (e) attachments 4. Types of drilling tools — (a) twist drills (b) centre drills (c) spade drills (d) machine reamers (e) counterbores (f) countersinks (g) spot facers (h) hole saws (i) machine taps (j) gun hole drillg (k) oil hole drill (l) selection and systems of sizing (m) handling (n) installations (o) removal (p) storage 5. Drill sharpening and modification (a) offhand grinding (b) drill grinding machines and attachments	1. List safety precautions that should be taken when performing drilling operations. 2. Describe good housekeeping practices. 3. List drill press tool holding devices. 4. Describe methods of sizing twist drills. 5. List types of drill press tools and their uses. 6. List drill press operations. 7. Describe drill press work holding methods. 8. Calculate correct drill press speeds and feeds. 9. Demonstrate proper drill press operations. 10. List maintenance and lubrication requirements of drilling machines.

TOPIC

- (c) drill point geometry
- (d) drill point modifications for various materials and operations

6. Types of work holding devices
   - (a) drill vises
   - (b) clamps, bolts and studs
   - (c) chucks
   - (d) drill jigs
   - (e) selection
   - (f) use
7. Operations performed on the drill press
   - (a) drilling
   - (b) reaming
   - (c) countersinking
   - (d) counterboring
   - (e) spot facing
   - (f) tapping
   - (g) hole sawing
   - (h) trepanning
   - (i) polishing
8. Speeds and feeds
   - (a) calculations
   - (b) selections
   - (c) applications
9. Maintenance requirements

B. Engine Lathe

1. Safety
   - (a) general
2. Parts
   - (a) functions
   - (b) limitations
3. Construction
4. Types
5. Sizes
6. Function of controls
7. Work holding devices
   - (a) chucks
   - (b) collets
   - (c) mandrels
   - (d) face plates
   - (e) centres
   - (f) lathe dogs
   - (g) drive plates
   - (h) lathe fixtures
8. Tool holding devices
9. Cutting tools
   - (a) shapes
   - (b) sizes
   - (c) types
   - (d) grinding procedures
   - (e) usage
   - (f) material

TERMINAL PERFORMANCE OBJECTIVES

1. List safety precautions pertaining to engine lathe operations.
2. List types of work holding devices.
3. List types of tool holding devices.
4. Describe types of engine lathe cutting tools and their geometry considerations.
5. Describe and demonstrate proper engine lathe tool grinding procedures.
6. Calculate and select proper cutting speeds and feeds, including metric requirements.
7. Demonstrate ability to properly set-up and operate an engine lathe including taper turning and threading.
8. Demonstrate ability to correct machining deficiencies such as vibration, tool chatter, etc.
9. Demonstrate good housekeeping practices.

TOPIC

TERMINAL PERFORMANCE OBJECTIVES

10. Speeds and feeds
    - (a) calculations
    - (b) selections
    - (c) applications
11. Lathe accessories
    - (a) steady rests
    - (b) follower rests
    - (c) taper attachments
    - (d) grinding attachments
    - (e) milling attachments
12. Lathe operations
    - (a) turning
        - (i) roughing
        - (ii) finishing
    - (b) facing
    - (c) grooving
    - (d) parting off
    - (e) boring and counterboring
    - (f) taper turning
    - (g) form and profile turning
    - (h) threading
        - (i) single point
        - (ii) taps and dies
        - (iii) centre and pitch gauges
    - (i) filing and deburring
    - (j) polishing
    - (k) drilling
    - (l) centre drilling
    - (m) reaming
    - (n) knurling
    - (o) turning between centres
13. Lathe attachments
    - (a) attachments for engine lathes
        - (i) taper
        - (ii) milling
        - (iii) grinding
    - (b) accessories for engine lathes
        - (i) steady rests
        - (ii) follow rests
        - (iii) face plates
        - (iv) use of toolmakers buttons
        - (v) catheads (spider) bushings
        - (vi) stops
        - (vii) boring table
        - (viii) spring winding

C. Milling Machines, Milling Operations and Cutters

1. Safety
    - (a) general
2. Principles of milling
    - (a) up and down milling
        - (i) advantages
        - (ii) limitations
3. Milling cutters
    - (a) types
        - (i) arbor

1. List safety precautions pertaining to milling machine operations.
2. List types of milling machine work holding devices.
3. List types of milling cutters, tool holders and their uses.
4. Describe various milling machine attachments, accessories and their uses.
5. Calculate and select proper millingm achine cutting speeds and feedrates.
6. Calculate and select required indexing.

TOPIC

        - (ii) shank
        - (iii) flycutters
        - (iv) fluted
        - (v) form relieved
    - (b) cutter material
    - (c) selection of proper cutters
    - (d) storage of cutters
    - (e) sizing of cutters

4. Workholding devices
    - (a) vises
    - (b) fixtures
    - (c) dividing heads
    - (d) clamping tools and accessories
    - (e) rotary tables

5. Toolholding devices
    - (a) arbors
    - (b) collets
    - (c) adaptors

6. Milling machine speeds and feeds
    - (a) calculations
    - (b) selection

7. Milling machine operations and set-ups
    - (a) plain milling
    - (b) face milling
    - (c) slitting
    - (d) slotting
    - (e) straddle milling
    - (f) gang milling
    - (g) end milling
    - (h) form milling
    - (i) boring
    - (j) graduating
    - (k) flycutting

8. Milling machine attachments
    - (a) vertical milling
    - (b) universal milling head
    - (c) rack milling attachment
    - (d) slotting attachment
    - (e) high speed milling attachment
    - (f) sine chucks
    - (g) tilting tables
    - (h) dividing head

9. Dividing head indexing
    - (a) direct
    - (b) simple or plain
    - (c) differential
    - (d) angular
    - (e) wide range dividing head

10. Helical milling
    - (a) principles
    - (b) calculations
        - (i) helix angle
        - (ii) lead
        - (iii) change gears
    - (c) short lead
        - (i) methods
    - (d) methods of producing helical work

TERMINAL PERFORMANCE OBJECTIVES

7. Calculate or source from manuals or tables the data required to properly set up a milling machine to perform helical milling.

8. Demonstrate ability to set up and operate milling machines, including angular and helical milling.

9. Demonstrate ability to correct milling deficiencies including tool/cutter chatter and vibration.

10. Demonstrate good housekeeping practices.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
D. Coolants	
1. Purpose 2. Types 3. Charts 4. Methods of applications	1. Identify and describe types of coolants available. 2. Explain purpose of coolants. 3. Select correct coolants for different materials and machine tool operations.
E. Shapers	
1. Safety (a) general 2. Cutting tools (a) types (b) material 3. Tool holders (a) types 4. Work holding devices (a) vises (b) clamps (c) fixtures (d) chucks (e) turntables (f) indexing devices 5. Cutting speeds and feeds 6. Operations (a) horizontal cutting (b) vertical cutting (c) angular surfaces (d) internal keyways (e) external keyways (f) splines (g) squares (h) hexagons (i) contour surfaces	1. List safety precautions to be taken when operating shapers. 2. Describe shaper cutting tools and tool holders. 3. Describe shaper and holding devices. 4. Calculate correct shaper cutting speeds and feet rates. 5. List operations performed on a shaper. 6. Demonstrate ability to set-up and operate shapers.
F. Broaching	
1. Safety (a) general 2. Hand broaching (a) type (b) tooling (c) set-ups 3. Machine broaching (a) types (b) tooling (c) set-ups (d) cutting speeds and feeds	1. List safety precautions pertaining to hand and machine broaching. 2. Describe tooling available. 3. Describe broaching set-ups. 4. Calculate cutting speeds and feeds for machine broaching. 5. Demonstrate correct broaching procedures.
G. Boring Mills	
1. Safety (a) general 2. Types (a) horizontal (b) vertical 3. Tooling	1. List safety precautions pertaining to boring mill operations. 2. Describe boring mill tooling and tool holders. 3. Calculate boring mill speeds and feeds. 4. Demonstrate correct boring mill set-up and operating procedures.

TOPIC — TERMINAL PERFORMANCE OBJECTIVES

4. Accessories
5. Operations
6. Set-ups
7. Applications

H. Computer Numerical Control Machine Tools (C.N.C.)

1. Safety
   (a) general
2. Types
3. Applications

1. List safety precautions pertaining to C.N.C. machine tools.
2. Identify the types of C.N.C. machine tools.
3. List C.N.C. machine tool applications and capabilities.

CUTTING TOOLS

1. Safety
   (a) general safety rules
   (b) fragmented inserts
   (c) chip control
   (d) fire hazards
   (e) health hazards
   (f) work piece holding safety
2. Tool materials
   (a) carbides
   (b) oxides
   (c) cast alloys
   (d) ceramics
   (e) diamond
   (f) H.S. steel developments
3. Standard designations (ANSI & SI)
   (a) inserts — turning and milling
   (b) turning tool holders
   (c) milling cutters
   (d) cartridges
   (e) API tool holders
   (f) qualified tool holders
4. Carbide applications
   (a) turning tools and holders
      (i) qualified
      (ii) external
      (iii) profiling
      (iv) threading, grooving, forming and parting
      (v) specific machining
      (vi) indexable inserts
   (b) milling cutters and holders
      (i) face mills
      (ii) shoulder face mills
      (iii) end mills
      (iv) side and face milling cutters
      (v) indexible inserts
      (vi) mounting
      (vii) accessories
      (viii) special cutters and holders
   (c) drilling tools, rotatingand nonrotating holders
      (i) brazed on

1. List safety precautions pertaining to cutting tool usage.
2. Describe cutting tool materials.
3. Describe carbide insert identification systems and tool holder standardization method.
4. Select correct insert for application performed.
5. Demonstrate proper cutting tool usage.
6. Describe the geometry of cutting tools.
7. List reasons for cutting tools geometry.
8. Calculate speed and feed requirements for different cutting tool materials and applications.
9. Describe and demonstrate tool grinding procedures.
10. List effects of grinding on different tool materials.
11. Describe types of boring bars.
12. Describe factors affecting boring bar usage.
13. Describe types of boring heads.
14. Describe factors affecting boring head usage.
15. Describe "angle of entry" requirements for milling cutters.
16. List reasons for cutting tool failure and describe remedial action.

      - (ii) solid
      - (iii) insert
      - (iv) trepanning
   - (d) blanks and brazed tools
      - (i) blanks
      - (ii) solid rod
      - (iii) brazed single point tools
      - (iv) brazed tools for automatics

5. Insert section
   - (a) shape
   - (b) size
   - (c) thickness
   - (d) style
   - (e) nose radius
   - (f) tolerance
   - (g) chip groove geometry
   - (h) coated inserts
   - (i) grade

6. Tool geometry
   - (a) rake angles
   - (b) lead angles
   - (c) clearance angles
   - (d) nose radius considerations

7. Operating conditions for carbide tools
   - (a) cutting speeds
   - (b) feeds
   - (c) depth in cut
   - (d) metal removal rates
   - (e) angle of entry for milling cutters

8. Grinding
   - (a) carbides
   - (b) milling cutters
   - (c) drills
   - (d) reamers
   - (e) high speed steel
   - (f) form cutters

9. Boring bars
   - (a) types
   - (b) applications
   - (c) operating factors

10. Boring heads
    - (a) types
    - (b) applications
    - (c) operating factors

11. Tool failure analysis
    - (a) normal flank wear
    - (b) cratering
    - (c) build-up edge
    - (d) chipping
    - (e) thermal cracking
    - (f) deformation
    - (g) notching
    - (h) fracture

TOPIC

TERMINAL PERFORMANCE OBJECTIVES

12. Trouble shooting
    - (a) chatter and vibration
    - (b) cutting tool holder problems
    - (c) miscellaneous problems

POWER SAWS AND MACHINE FILING

1. Safety
    - (a) general
2. Types
    - (a) power hack saws
    - (b) circular cut off saws
    - (c) band saws
        - (i) vertical
        - (ii) horizontal
    - (d) abrasive cut off machines
3. Blades
    - (a) types
    - (b) uses
    - (c) welding
    - (d) selection
4. Speeds and feeds
5. Power feed attachments
6. Power saw operations
    - (a) profile sawing
    - (b) friction sawing
    - (c) stock cutting including multiple cutting
7. File machines
    - (a) reciproacting
    - (b) band
    - (c) operations

1. List safety precautions pertaining to power saw and filing machine operations.
2. Describe operations performed on power saws.
3. Select proper types of band or wheels.
4. Calculate power sawing and filing speeds and feeds.
5. Demonstrate correct power saw and filing procedures.
6. Explain purpose of file machine operations.

GRINDING

A. Grinding Safety

1. Eye protection
    - (a) safety glasses
    - (b) goggles
    - (c) face shields
2. Clothing
    - (a) protective
    - (b) footwear
3. Machine start-up
4. Housekeeping

1. List reasons for wearing proper eye protection.
2. Describe proper clothing to be worn when working on grinders.
3. Describe proper grinding machine start-up procedures, including reasons for precautions.
4. Describe/demonstrate good housekeeping practices.
5. List methods used to test grinding wheels for cracks.
6. Demonstrate safe grinding practices.

B. Abrasive Products

1. Types
    - (a) manufactured
    - (b) natural
2. Grinding wheels
    - (a) manufacturing process
    - (b) types
    - (c) shapes
    - (d) identification

1. List types of natural and manufactured abrasives available.
2. Describe standard grinding wheel marking system.
3. Describe common grinding wheel shapes.
4. Describe/demonstrate proper grinding wheel balancing and truing procedures.
5. Describe/demonstrate proper grinding wheel mounting procedures.

    - (e) truing
    - (f) testing for cracks
    - (g) balancing
    - (h) applications
3. Mounted grinding wheels
    - (a) types
    - (b) identification
    - (c) uses
    - (d) mounting

C. Grinding Wheel Dressing Techniques

1. Form dressing
2. Crush forming
3. Concentric and parallel face dressing (truing)
    - (a) single point diamond dresser
    - (b) diamond cluster dressers
4. Diaformed formed grinding wheel dresser.

1. Describe form dressing.
2. Describe crush forming.
3. Describe concentric and parallel face dressing.
4. Demonstrate safe dressing techniques.
5. List reasons for dressing grinding wheels.
6. Understand wheel form shaping methods.

D. Coated Abrasives

1. Types of backing
2. Types of abrasives
3. Grades for hand operations
4. Grades for machine operations

1. Describe coated abrasives and their uses.

GRINDING MACHINES

A. Safety

1. Machine operation
    - (a) wheel mounting
    - (b) machine start-up
    - (c) operating hazards
2. Grinding processes
    - (a) feeds
    - (b) speeds
    - (c) surface finishes
    - (d) depth of cuts
3. Work holding devices
    - (a) magnetic chucks
    - (b) vises
    - (c) "V" blocks
    - (d) clamps
    - (e) parallels
    - (f) fixtures
    - (g) chucks
    - (h) between centres
4. Grinding fluids
    - (a) types
    - (b) methods of application
5. Surface grinders
    - (a) types
    - (b) wheel arrangement
    - (c) table arrangement

1. List proper grinding wheel mounting procedures.
2. Describe grinding machine start-up precautions.
3. List common grinding machine operating hazards.
4. Calculate correct grinding speeds, feeds, and depth of cut.
5. List types of grinding fluids, their purpose and application.
6. Describe operations performed on surface grinders.
7. Demonstrate safe, proper workholding methods and and set-ups for grinders.
8. List common methods of grinding oncylindrical grinding machines.
9. List advantages of different grinding machines.

TOPIC — TERMINAL PERFORMANCE OBJECTIVES

- (d) nomenclature
- (e) controls
- (f) operations
- (g) set-ups

6. Cylindrical grinders
    - (a) types
    - (b) wheel arrangements
    - (c) table arrangement
    - (d) nomenclature
    - (e) control
    - (f) operation
    - (g) set-up
    - (h) plunge grinding
    - (i) traverse grinding
    - (j) shoulder grinding
    - (k) internal grinding
    - (l) taper grinding
    - (m) production grinding
    - (n) electrolytic grinding

B. Tool and Cutter Grinding

1. Types of machines
2. Controls
3. Operations
4. Attachments
    - (a) surface grinding
    - (b) cylindrical grinding
    - (c) internal grinding
    - (d) gear cutter sharpening
    - (e) small end mill
    - (f) radius grinding
5. Optical form grinding

1. List operations performed on a tool and cutter grinder.
2. Know operations performed on a tooland cutter grinder.
3. Know optical form grinding regarding tool and cutter operations.
4. Perform precision tools and cutter grinding, including form grinding as required.

C. Precision Jig Grinding Machines, Tools and Processes

1. Safety and eye protection
2. Design features of jig grinders
    - (a) base and column
    - (b) main spindle assembly
    - (c) jig grinding heads
3. Operations
    - (a) outfeed grinding
    - (b) plunge grinding
    - (c) taper grinding
    - (d) shoulder grinding
    - (e) slot grinding
4. Jig grinding wheel selection
    - (a) material to be ground
    - (b) bond
    - (c) grit
    - (d) diameter
5. Grinding wheel dressing attachments
    - (a) radius angle grinding
    - (b) cross slide dressing
    - (c) angle type dressing
    - (d) pantograph dressing

1. List safe operation practices forjig grinders.
2. Identify jig grinding machines design features.
3. List operation performed on jig grinders.
4. Demonstrate proper set-up and operating procedures.
5. Select correct grinding wheel and demonstrate proper mounting.
6. Demonstrate proper grinding wheel dressing.
7. List jig grinding wheel dressing attachments and describe their uses.
8. Calculate proper grinding wheel and mandrel speeds.
9. Select correct tooling for set-ups.
10. Demonstrate correct clamping procedures.
11. Demagnatize if magnetic chuck used.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
6. Grinding wheel and mandrel speeds (a) grinding wheel S.F.M. (b) diamond charged mandrels	
7. Jig grinder set-up requirements (a) tooling (b) correct work piece location procedures (c) distortion	

MICRO FINISHING, POLISHING OPERATIONS

A. Safety	
1. Eye protection 2. Machine start-up	1. List proper eye protection devices. 2. Describe proper machine start-up procedures.
B. Honing	
1. Types of honing machines (a) vertical (b) horizontal (c) drill operated 2. Abrasive honing stones (a) grit size (b) tolerances (c) cutting speeds and motions (d) coolants	1. Describe types of honing machines and their operations. 2. Select and mount proper honing stones. 3. Demonstrate honing operations. 4. List tolerances expected from honing operations. 5. Demonstrate proper honing cutting speeds and motions. 6. List proper coolants.
C. Lapping	
1. Types of laps (a) soft cast iron (b) copper (c) brass (d) lead 2. Operations (a) cylindrical holes (b) flat surfaces (c) rotary diamond lap (d) grading (e) uses and lap wear 4. Charging laps (a) flat (b) cylindrical 5. Lapping lubricants (a) types (b) uses	1. Describe the types of laps available and their uses. 2. Describe lap operations. 3. Identify lap abrasives. 4. Select correct lap abrasive. 5. Describe lap charging. 6. List lapping lubricants and their uses.
D. Polishing/Finishing Operations	
1. Safety 2. Buffing (a) wheels (b) buffing compounds (c) applications 3. Stoning (a) stone grit grades (b) air machines (c) applications	1. List safety considerations pertaining to polishing finishing operations. 2. Demonstrate buffing techniques. 3. Select correct buffing/dressing sticks. 4. Select stones for stoning operations. 5. Demonstrate stoning techniques. 6. List operations performed by air grinders. 7. Select correct attachments for operations performed.

TOPIC

4. Air grinders
   (a) attachments
   (b) applications
5. Finish filing
   (a) types of files
   (b) hand files
   (c) filing machines
   (d) applications

TERMINAL PERFORMANCE OBJECTIVES

8. Select suitable files for operation to be performed.
9. Demonstrate filing techniques.

GEAR AND SPLINE CUTTING

1. Gears
   (a) types
      (i) spur
      (ii) helical
      (iii) bevel
      (iv) worm
      (v) hypoid
      (vi) mitre
      (vii) rack and pinion
      (viii) herringbone
   (b) calculations for spur, helical and rack
   (c) nomenclature
   (d) types of teeth
   (e) methods of manufacturing and finishing
   (f) materials use in manufacturing gears
   (g) heat treatment of gears
2. Gear cutters
   (a) types
      (i) hob
      (ii) involute
      (iii) fly
   (b) identification
   (c) pressure angles
3. Gear tooth measurement
   (a) tables
   (b) methods
      (i) vernier caliper
      (ii) wire or pins
   (c) backlash
4. Splines
   (a) types
   (b) manufacturing

1. List safety precautions pertaining to gear cutting.
2. Describe, using gear nomenclature, gear and rack teeth parts.
3. List gear manufacturing methods.
4. Describe materials used for gear manufactures and reasons for usage.
5. Calculate or source information necessary to manufacture gears.
6. List methods and reasons for heat treatment gears.
7. Select proper gear cutter.
8. Demonstrate ability to set-up necessary machine tools to cut gears.
9. List methods used to measure gear teeth.
10. List types of splines.
11. Describe spline cutting methods.
12. Demonstrate ability to set-up necessary machines to cut a spline.

JIGS AND FIXTURES

1. Safety
   (a) general
2. Types of jigs and fixtures
   (a) drill jigs
   (b) drill templates
   (c) milling fixtures
   (d) assembly fixture
   (e) welding fixtures
   (f) production jigs

1. List safety considerations pertaining to jigs and fixtures.
2. Define a jig.
3. Define a fixture.
4. Describe common types of jigs and fixtures.
5. List jig and fixture design considerations.
6. Describe jig and fixture work piece locating methods.
7. Describe work clamping devices used in jig and fixtures.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
(g) other	8. Demonstrate setting up jigs and fixtures for use.
3. Robotics (a) pneumatic (b) mechanical (c) hydraulic	
4. Principles of Designs	
5. Locating methods (a) tooling for occasion	
6. Clamping devices (a) methods (b) types (c) applications	

GAUGES AND GAUGE FIXTURES

A. Characteristics of Go and No-go Gauges	
1. Use of go and no-go gauges	1. Demonstrate proper use and care of go and no-go gauges.
B. Types of Gauges	
1. Cylindrical plug gauges	1. Demonstrate proper usage of various gauges as required.
2. Plain ring gauges	2. List gauge applications.
3. Taper plug gauges	3. Demonstrate gauge adjustment methods.
4. Taperring gauges	4. List correct storage procedures forgauges.
5. Thread plug gauges	5. Select best wire size for thread measurement using three wire method.
6. Thread ring gauges (a) adjustable thread ring gauge	6. Calculate thread measurement "over the wires".
7. Snap gauges (a) adjustable snap gauges (b) adjustable roll snap gauges (c) dial indicator snap gauges	
8. Thread wire measurement (a) best wire size (b) three wire measurement	

PRESS WORK — PUNCHES AND DIES

A. Presses	
1. Safety (a) press controls (b) safety attachments (c) operator training	1. List press control safety features. 2. Describe press safety attachments. 3. Describe importance of operator training. 4. List safety rules pertaining to press operators.
2. Types (a) types of presses (b) functions (c) adjustments (d) set-ups (e) lubrication and maintenance	5. Identify major types of presses. 6. Describe press functions. 7. Describe/demonstrate proper set-up and adjustment procedures.
3. Shut Height, Die Space Requirements (a) requirements (b) calculations (c) die space requirement	1. Describe shut height requirements. 2. Calculate required shut height distance. 3. Describe die space requirements.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
B. Types of Punches and Dies	
1. Simple dies (a) blanking (b) piercing	1. Identify types of common punches and dies. 2. List operations performed with the various types of punches and dies.
2. Progressive dies	3. Demonstrate safe set-up and operating procedures.
3. Compund dies	4. When required, demonstrate proper feed mechanism set-up.
4. Bending dies	
5. Forming dies (a) forming process	
6. Draw dies	
7. Deep draw dies	
8. Cut-off dies	
9. Scrap disposal	
10. Trimming dies	
11. Embossing dies	
12. Coining dies	
13. Perforating dies	
14. Steel rule dies	
15. Zinc and aluminum die cast dies	
16. Accessories (a) feeders	
C. Manufacturing and Design of Punches and Die Sets	
1. Tooling economics	1. When required, devise, design and detail simple punch and die sets.
2. Material considerations	2. Demonstrate knowledge of punch and die set construction.
3. Process planning	3. List common punch and die set components.
4. Use of commercial (off the shelf) components	4. Select material to construct punch and die sets. 5. Demonstrate planning required to build punch and die sets.
5. Stripping requirements	6. Describe stripping requirements.
6. Material stretch factors	7. Demonstrate ability to calculate or source required clearance, spring back and press tonnage needs.
7. Clearance calculations	
8. Hold down pressures	8. Demonstrate ability to construct required punch and die sets.
9. Spring back calculations	9. List and demonstrate punch and die set maintenance procedures.
10. Press tonnage calculations	
11. Heating and cooling requirements	
12. Maintenance	
D. Die Sinking	
1. Safety	1. List safety precautions pertaining to die sinking.
2. Methods of Manufacturing (a) electro-discharge machining (E.D.M.) (b) pantograph (c) computer numerical control machining (CNC) (d) tracer mills	2. Identify methods of metal removing and list advantages of each.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
3. Familiarization with equipment 4. Controls and settings 5. Electrodes (a) numerical definitions (b) functions to the coating (c) functions of the slag 6. Striking and maintaining an arc 7. Running practice beads 8. Make tack welds (butt and fillet) Safety precautions should be emphasized prior to, during and after use.	7. Describe use and care for cables, electrode holders, rods, helmets, gloves, etc. 8. Demonstrate practical arc welding procedures.
C. Tool Steel Welding 1. Material (a) pre-heating (b) post-heating (c) cooling	1. Demonstrate ability to obtain and use steel manufacturers specifications regarding pre-heating and post-heating operations.
D. Oxyacetylene Heat Treatment 1. Safety 2. Applications 3. Methods	1. List safety precautions pertaining to oxyacetylene heat treatment. 2. Demonstrate oxyacetylene heat treatment methods.

QUALITY CONTROL

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
A. Types of Measurement 1. Angular 2. Co-ordinate 3. Diametral 4. Gear tooth 5. Incremental 6. Linear 7. Optical 8. Precision 9. Surface finish	1. List various types of measuring techniques. 2. Perform optical, visual inspections. 3. List reasons for quality control. 4. Identify surface finish symbols.
B. Measurement Instruments 1. Angle plates 2. Dial test indicators 3. Fixed-size gauges 4. Adjustable gauges 5. Gauge blocks 6. Gear tooth vernier calipers 7. Height gauges 8. High amplication comparators 9. Mechanical comparators	1. Demonstrate the use measuring instruments. 2. Identify and describe measuring instruments. 3. Describe surface finish measurement methods. 4. Demonstrate the calibration of measuring instruments. 5. Select machining processes for given tolerances and to produce given finishes. 6. Demonstrate care and maintenance of measuring devices.

TOPIC

- (iii) construction and sizes
- (iv) handling, storage and transporting
- (v) safety features
- (vi) faulty cylinders

(b) regulators
- (i) types and identification
- (ii) proper use and construction
- (iii) safety features
- (iv) proper storage and maintenance

(c) oxyacetylene hoses
- (i) construction sizes
- (ii) identification of
- (iii) safety repair and maintenance

(d) cutting tips
- (i) design and construction
- (ii) operating principles
- (iii) care and maintenance
- (iv) tip cleaners and drills
- (v) tip selection

(e) setting up equipment
- (i) placement and securing cylinders
- (ii) clearing and checking cylinders valves
- (iii) precautions taken in checking and attaching regulators
- (iv) attaching torch
- (v) correct procedure in checking for leaks

(f) gas pressure and flame adjustment
- (i) regulator adjustment and balancing pressure
- (ii) backfires and backflash
- (iii) igniting and flame adjustments
- (iv) shutting down procedures

(g) maunual cutting
- (i) torch styles
- (ii) preheating and starting a cut
- (iii) practice cuts on various thicknesses
- (iv) piercing holes and shape cutting
- (v) straight and bevel cutting

TERMINAL PERFORMANCE OBJECTIVES

3. Change and read types of regulators.
4. List and describe purpose of hose coloring.
5. List and describe types of torches.
6. Describe procedure for setting up oxy-fuel equipment.
7. Describe correct procedure for lighting torch including correct pressures.
8. Describe procedure for shutting down oxy-fuel equipment.
9. Select torch tip and describe correct tip cleaning procedures.
10. Describe silver soldering and brazing procedures.
11. Describe safe cutting procedures.

B. Electric Arc Welding

1. Clothing and equipment
   - (a) proper apparel
   - (b) description of welding helmet and placement of lens
   - (c) proper housekeeping practices
2. Type of machines (manual)
   - (a) functions of volts and amperes

1. List safety precautions pertaining to arc welding.
2. List and describe components of arc welding equipment.
3. Describe required arc welder processes.
4. Select proper welding electrodes.
5. Describe correct procedures for starting arc welding equipment.
6. Describe/demonstrate setting welding machine and testing setting.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
3. Familiarization with equipment 4. Controls and settings 5. Electrodes (a) numerical definitions (b) functions to the coating (c) functions of the slag 6. Striking and maintaining an arc 7. Running practice beads 8. Make tack welds (butt and fillet) Safety precautions should be emphasized prior to, during and after use.	7. Describe use and care for cables, electrode holders, rods, helmets, gloves, etc. 8. Demonstrate practical arc welding procedures.
C. Tool Steel Welding	
1. Material (a) pre-heating (b) post-heating (c) cooling	1. Demonstrate ability to obtain and use steel manufacturers specifications regarding pre-heating and post-heating operations.
D. Oxyacetylene Heat Treatment	
1. Safety 2. Applications 3. Methods	1. List safety precautions pertaining to oxyacetylene heat treatment. 2. Demonstrate oxyacetylene heat treatment methods.
	QUALITY CONTROL
A. Types of Measurement	
1. Angular 2. Co-ordinate 3. Diametral 4. Gear tooth 5. Incremental 6. Linear 7. Optical 8. Precision 9. Surface finish	1. List various types of measuring techniques. 2. Perform optical, visual inspections. 3. List reasons for quality control. 4. Identify surface finish symbols.
B. Measurement Instruments	
1. Angle plates 2. Dial test indicators 3. Fixed-size gauges 4. Adjustable gauges 5. Gauge blocks 6. Gear tooth vernier calipers 7. Height gauges 8. High amplication comparators 9. Mechanical comparators	1. Demonstrate the use measuring instruments. 2. Identify and describe measuring instruments. 3. Describe surface finish measurement methods. 4. Demonstrate the calibration of measuring instruments. 5. Select machining processes for given tolerances and to produce given finishes. 6. Demonstrate care and maintenance of measuring devices.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
10. Mechanical-optical comparators	
11. Microscopes	
12. Optical flats	
13. Parallels	
14. Protractors	
15. Sine bars	
16. Sine plates	
17. Surface plates	
18. Surface finish analyzer	
19. Precision squares	
20. Calipers	
C. Systems of Limits and Fits	
1. Limits of size	1. Describe systems of limits and fits.
2. Tolerances	2. Identify application of limits and fits systems.
3. Allowances	3. Demonstrate knowledge of standards.
4. Types of fits	
5. Standards	
D. Measurement of Hole Position	
1. Layout	1. Demonstrate accurate hole position measurement.
2. Indirect measurement	2. Describe various methods of accurately locating hole position.
3. Centre distance	
4. Small hole locations	
E. Concentricity Measurement	
1. Required equipment (a) surface plate (b) dead centers (c) dial indicators	1. Describe method of determining concentricity. 2. Demonstrate concentricity measurement.
F. Eccentricity Measurement (Axial Runout)	
1. Required equipment (a) bench center (b) surface plate (c) mounted dial indicator	1. Describe method of determining eccentricity. 2. Demonstrate eccentricity measurement.
G. Non-Destructive Testing (N.D.T.)	
1. Magneflux	1. List non-destructive testing methods.
2. X-rays	2. Understand importance of non-destructive testing.
3. Dyes	
H. Communication Skills	
1. Verbal	1. Understand importance of various communication methods.
2. Written	2. Demonstrate ability to communicate effectively.
3. Listening	
4. Reading	

METALLURGY

TOPIC

1. Safety
    - (a) general
2. Materials
    - (a) carbon steels
    - (b) alloy steels
    - (c) nonferrous metals
    - (d) high temperature metals
    - (e) finishing processes
3. Steel classification and identification systems
    - (a) SAE system
    - (b) AISI system
    - (c) color codes
4. Physical properties of metals
    - (a) mechanical properties
    - (b) hardness
    - (c) strength
    - (d) brittleness
    - (e) ductility
    - (f) wear resistance
    - (g) corrosion resistance
    - (h) conductivity
    - (i) thermal properties
    - (j) work hardening
5. Hardness
    - (a) relation of hardness to other properties
    - (b) penetration hardness
    - (c) scratch hardness
    - (d) units of hardness
    - (e) hardness testing methods
        - (i) brinell
        - (ii) rockwell
6. Heat treating and quenching
    - (a) terminology
    - (b) quenching
    - (c) quenching mediums
        - (i) water
        - (ii) oil
        - (iii) air
        - (iv) brine
    - (d) effects of quenching mediums
        - (i) hardness
        - (ii) strength
        - (iii) ductility
    - (e) effects of temperature
    - (f) quenching techniques
7. Annealing and normalizing
    - (a) purpose
    - (b) effects of annealing and normalizing
    - (c) full annealing
8. Tempering
    - (a) purpose
    - (b) effects of tempering on materials

TERMINAL PERFORMANCE OBJECTIVES

1. List safety precautions pertaining to heat treating operations.
2. List what affects alloys have on metals.
3. Describe the properties of different types of steel.
4. Identify steel classification and identification systems.
5. Describe methods of determining thehardness of metal.
6. Demonstrate use of brinell and metal rockwell methods.
7. Translate from one hardness value to another.
8. Describe quenching.
9. List types of quenching media and their effects on metal.
10. Demonstrate proper quenching techniques.
11. Describe the difference between annealing and normalizing.
12. Explain purpose of tempering.
13. Describe effect of tempering regarding distortion and hardness.
14. Describe tempering methods.
15. Describe surface and case hardening.
16. List advantages and disadvantages of surface and case hardening.
17. List equipment used for heat treatment.
18. Describe purpose of stress relieving.

- (c) effects of tempering time on materials

9. Surface hardening
    - (a) purpose
    - (b) surface/case hardening
        - (i) cyaniding
        - (ii) flame hardening
        - (iii) induction hardening

10. Heat treating equipment
    - (a) furnaces
    - (b) oxyacetylene

11. Stress relieving
    - (a) purpose
    - (b) methods

BLUEPRINT READING AND INTERPRETATION

A. Isometric and Orthographic Views

1. Orthographic projection
    - (a) 6 views and their relative positions
    - (b) the "key" view
    - (c) the three common views
    - (d) sketching various views
    - (e) uses of two view projection
    - (f) first and third angle projections
    - (g) I.S.O. projection symbols

2. Estimating dimensions

3. Isometric sketches

4. Sketching and dimensioning orthographic projection views

1. Describe and sketch orthographic and isometric views.
2. Identify I.S.O. projection symbols.
3. Interpret orthographic views.
4. Interpret isometric sketches.

B. Dimensioning

1. Lines and their applications
    - (a) visible and centre lines
    - (b) dashed or hidden lines
    - (c) dimension, extension and leader lines

2. Dimensioning methods
    - (a) arrowheads and dimensions inside extension lines
    - (b) leader lines
    - (c) arrowheads outside and dimensions inside extension lines
    - (d) arrowheads and dimensions outside the extension lines.
    - (e) arrowheads inside and dimension outside the extension lines
    - (f) datum line and symbols

3. Dimensioning tapers and angles
    - (a) amount of taper
    - (b) large or small diameter
    - (c) length of taper

1. Describe types of lines used on blueprints.
2. Describe proper blueprint dimensioning including common terminology notes.
3. Identify information given on blueprints that enables accurate component machining.
4. Interpret "dual dimensioned" blueprints.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
4. Dimensioning holes, circles, chamfers, arcs, threads, countersinks, drills, bores, spotfacing and radii (a) methods and their applications (b) notes on blueprints (c) abbreviations on blueprints	
5. Dual dimension on blueprints	
C. Sectioning	
1. Sectioning (a) full (b) half (c) removed (d) revolved (e) partial (f) purpose and application 2. Cutting plane and symmetry 3. Methods of indicating cutting plane lines 4. Section lines (a) general purpose and cast iron (b) steel, brass, bronze and aluminum 5. Parts requiring no sectioning (a) pins, rivets, screws, etc. 6. Conventional breaks (a) for round and rectangular objects (b) purpose of such breaks	1. Identify cutting plane lines on blueprints. 2. Identify material symbols, i.e. cast iron, steel, aluminum, etc. 3. Sketch sectional views. 4. Interpret sectional views.
D. Symbols, Tolerances	
1. Limits, fits and tolerance (a) definitions (b) applications (c) symbols (d) accumulation of tolerances	1. Read blueprints including information relating to tolerances, limits and fits. 2. Interpret information relating to tolerances, limits and fits. 3. Interpret standards correctly.
E. Other Blueprint Reading Considerations	
1. Surface finish symbols 2. Welding specifications (a) American standard systems (b) types of joints (c) identification (d) indication 3. Auxiliary planes	1. Identify and interpret surface finish symbols. 2. Identify standard welding symbols. 3. Interpret auxiliary planes.
F. Casting Blueprints	
1. Design considerations (a) shrinkage allowances (b) machining allowances (c) cooling stresses (d) draft (e) tolerances (f) fillets and radii	1. Interpret information provided on casting blueprints.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
G. Arrowless (Co-ordinate) Dimensioning	
1. Arrowless dimensioning applications (a) numerical control (b) jig borer and jig grinder 2. Zero postions (a) centre locations (b) corner locations (c) outside locations (d) other locations within the workpiece 3. Datum and point to point dimensioning (a) applications (b) tolerance considerations 4. True-position dimensioning (a) geometric tolerancing (b) symbols	1. Identify purpose of arrowless dimensioning. 2. Explain applications of zero positioning. 3. Describe datum and point to point dimensioning. 4. Describe true point dimensioning.
H. Commercial Shapes	
1. Steel and nonferrous metals (a) round (b) hex (c) octagon (d) squareg (e) rectangular (f) pipe (g) angle (h) I-beam (i) U-channel (j) H-beam (k) T-bar (l) Z-bar (m) square, rectangular channel	1. Identify commercial shapes of steel and nonferrous metals. 2. Describe methods of identifying steel, and nonferrous metals.
I. Fasteners and Bearings	
1. Sketching screw threads (a) pictorial (b) schematic (c) simplified 2. Thread specifications (a) O.D. and number of threads (b) thread series (c) external or internal (d) class of fit (e) hand of thread 3. Terminology (a) blind hole (b) tap drill sizes 4. Fasteners (a) head and point sizes (b) fastener specifications (c) finished and semi-finished (d) types of threaded fasteners (e) styles of head recesses (f) types of nonthreaded fasteners	1. Sketch external and internal threads and know terminology for the same. 2. Identify information given in thread specifications. 3. Identify and sketch common types ofkeys and bearings. 4. Identify and sketch various types of fasteners including head style and list their specifications.

TOPIC — TERMINAL PERFORMANCE OBJECTIVES

5. Keys, keyways and keyseats
    (a) types and their specifications on blueprint
    (b) sketching keyways and keyseats

6. Bearings
    (a) plain and antifriction
    (b) how to sketch bearings
    (c) how to indicate bearing specifications on blueprints

7. Other fasteners
    (a) washers, nuts, pins
    (b) springs, rivets

J. Tool and Die Design

1. Principles of design
    (a) concepts
    (b) components
    (c) detail drawings
    (d) assembly drawings
    (e) abbreviations
    (f) symbols
        (i) D.I.N.
        (ii) A.N.S.I.
        (iii) CSA
    (g) material list
    (h) conversions
        (i) imperial to SI
        (ii) SI to imperial

1. Understand concepts of Tool and Die design.
2. Identify individual components.
3. Understand detail drawings.
4. Understand assembly drawings.
5. Identify and understand abbreviations and symbols.
6. Determine materials required.
7. Calculate necessary conversions.

K. Estimasting

1. Bill of material

2. Job planning
    (a) correct sequence of machine operations
    (b) equipment requirements
    (c) tooling requirements
    (d) cutting time calculations
    (e) tolerance and surface finish considerations

3. Cost estimating
    (a) fixed and variable costs
    (b) types of estimates

1. Interpret bill of material.
2. Identify factors affecting job planning.
3. Estimate time to complete job.
4. Estimate costs.

MATHEMATICS

A. Whole Numbers, Fractions and Decimals

1. The number line
    (a) whole numbers

2. Fractions
    (a) common
    (b) proper
    (c) decimal
    (d) improper
    (e) lowest common denominator
    (f) lowest term of fraction

1. Perform basic numeric calculations as required.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
3. Mixed numbers	
4. Basic calculations (a) adding (b) multiplying (c) subtracting (d) dividing (e) signs of operation	
5. Rounding off (a) principles (b) applications	
B. Percentages	
1. Expressing percent (a) decimal fractions (b) decimal numbers (c) fractions	1. Calculate percent from decimal fractions, decimal numbers, fractions ratio and proportion andvice versa.
2. Calculating percent (a) by ratio and proportion (b) by fractions and multiplication	
C. Tables, Graphs and Nomographs	
1. Decimal equivalent tables	1. Read and interpret tables and graphs available to provide information to the Tool and Die Maker.
2. Conversion tables	
3. Tap drill tables	
4. Taper and angle tables	
5. Tables of squares	
6. Tables of cubes	
7. Tables of square roots	
8. Tables of cube roots	
9. Area of circle tables	
10. Tables of morse and std. milling tapers	
11. Tables of number and letter drills	
12. Temperature range graphs for various heat treatment operations	
13. Machinability rating tables	
14. Cutting fluid tables for various materials and operations	
15. Tables of cutting geometry	
16. Charts for: (a) bandsaw selections and speeds (b) milling speed tables (c) milling feed tables (d) change gear table for differential indexing (e) change gear tables for helical milling (f) tables of weights (masses) (g) charts used in heat treating of steels (h) others as applicable to the trade	

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
D. D.I.N. Standardizations	1. Understand D.I.N. norms. 2. Identify and interpret D.I.N. specifications. 3. Understand D.I.N. applications.
E. Applied Geometry 1. Terminology used in applied geometry (a) parallelogram (b) frustrums (c) sector of a circle (d) segment of a circle (e) tangent line (f) quadrilateral (g) ellipse (h) trapezoids (i) cylinder (j) cone (k) pyramid (l) prisms (m) sphere (n) inscribed circle (o) circumscribed circle (p) polygon 2. Terminology of triangles (a) isosceles (b) right (c) equilateral (d) oblique 3. Parts of triangles (a) right angle (b) acute angle (c) obtuse angle (d) hypotenuse (e) base (f) altitude 4. The Pythagorean theorem 5. Special triangles (a) 30-60-90 (b) 45-45-90 (c) 3-4-5 (d) 5-12-13 6. Areas of triangle (a) right (b) isosceles (c) base altitude (d) three side method 7. Circle calculations (a) segments (b) sectors (c) areas (d) circumference 8. Area of ellipse 9. Area of trapezoid	1. Describe common geometric forms. 2. Calculate problems involving triangles, trapezoids, ellipses. 3. Calculate volume and weight of cylinder cones, prisms, spheres and frustrums of cones. 4. Identify common triangles and theirparts. 5. Identify and demonstrate usage of the theory of Pythagorus. 6. Demonstrate use of ratio and proportion using triangles to solve shop problems.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
10. Volume and weight (mass) calculations (a) cylinders (b) cones (c) prisms (d) spheres	
11. Area and volume calculations by similar-figure method	
F. Trigonometry	
1. Terminology (a) trigonometric functions or ratios (b) adjacent and opposite sides (c) hypotenuse (d) sine, cosine and tangent 2. Trigonometric ratios (a) sine (b) cosine (c) tangent 3. Trigonometric functions (a) tables (b) calculators 4. Solving for parts of triangles (a) right (b) equilateral (c) isosceles	1. Identify and describe trigonometric terms including trigonometric ratio. 2. Use tables of natural trigonometric functions to calculate values for angles. 3. Solve for parts of right triangles.
G. Shop Applications of Trigonometry	
1. Applications (a) thread forms (i) "V" (ii) acme (iii) worm (b) taper and bevel calculations (c) bevel and helical gearing (d) sine bar and sine centres (e) drill point geometry (f) tool clearance angle calculations (g) hole locations on bolt circles (h) dovetail and V-block calculations (i) helix angles (j) bolt hole circles and coordinate distances	1. Perform necessary sine bar calculations. 2. Calculate helix angles. 3. Use trigonometry to solve common shop problems.
H. Measurements and Conversions	
1. Imperial System (inch) 2. Terminology of the SI units for (a) linear (b) area (c) volume (d) liquid (e) mass (f) flexibility of the SI units (g) conversion charts	1. Convert feet into inches, inches into feet. 2. Convert degrees into minutes, seconds and second, minutes into degrees. 3. Convert into metric.

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
3. Conversion factors (a) inch to feet, etc. (b) millimeters to metres, etc. (c) SI to imperial and vice versa (d) angular conversions (i) degrees (ii) minutes (iii) seconds (iv) decimal equivalent	
I. Metric Problems	
1. Calculations in the metric system involving (a) cutting speeds (b) threads (c) tapers (d) feeds (e) speeds (f) module gears (g) module worms	1. Calculate trade problems involving the metric system.
2. Pressures (a) PSI to kilopascals and vice versa	1. Calculate conversion from pounds per square inch (PSI) to kilopascals (kap) and vice versa.
3. Any other problems arising in the tool and die shop due to metric conversion	
K. Indexing	
1. Plain	1. Calculate plain, angular and differential indexing.
2. Angular	2. Determine correct gearing for differential indexing.
3. Differential	
L. Formulae and Equations	
1. Threads (a) pitch and lead (b) tap drill size (c) depth of thread (i) internal (ii) external (d) amount of infeed (e) diameter of number screw threads	1. Calculate necessary values used to produce accurate threads. 2. Calculate information necessary to accurately machine tapers. 3. Determine correct speeds and feeds for lathes, milling machines, drills, grinders, etc. 4. Calculate circle circumferences, and areas.
2. Tapers (a) amount of taper (b) taper per foot (c) taper per inch (d) taper ratio (e) amount of taper gauge advance (f) tail stock offset	
3. Speeds and feeds (a) RPM for drilling, milling, lathe and grinder work (b) cutting speeds (c) feed rates	

TOPIC	TERMINAL PERFORMANCE OBJECTIVES
4. Others (a) circumference of circles (b) area of circles (c) simple indexing (d) angular set-ups	
M. Ratio and Proportion	
1. Terminology (a) ratio (b) proportion (c) extremes and means	1. Define and use ratio and proportion to calculate and solve shop problems. 2. Calculate pulley and gear problems using ratio and proportion methods.
2. Application of ratio and proportion (a) single pulleys and gear trains (b) compound pulley, spur and worm gear systems (i) speeds (ii) diameters (iii) teeth (c) proportions of alloy compositions	
N. Clearance Calculations	
1. Punches and dies	1. Calculate required cutting clearance for blanking and preforating operations. 2. Apply chart or graph data to punch and die cutting clearances requirements.
O. Pressure Calculations	
1. Punches and dies 2. Hydraulic pressures	1. Calculate required pressure for punching holes and forms from sheetsteel (tonnage requirements). 2. Understand die tonnage requirements. 3. Calculate stripping pressure on blanking and draw dies. 4. Calculate hold down pressure on forming and punching dies. 5. Calculate hydraulic pressure related problems.
P. Speed Calculations	
1. Presses	1. Calculate necessary press speeds for cutting dies.
2. Cutting speeds	2. Calculate necessary machine tool cutting speeds.
3. Feeds	3. Calculate proper machines tool cutting feeds.
Q. Bending Allowances	
1. Sheet metal	1. List stretch length considerations.
2. Flat stock	2. Calculate bending allowances.
3. Round stock	3. Apply chart data to bending problems.
R. Shrinkage and Expansion Factors	
1. Tool steels and non-ferrous metals	1. Calculate tool steel and non- ferrous metals during hardening processes.
2. Dies	2. Calculate required shrinkage or expansion factors as required.
3. Forging dies	
4. Extrusion moulds	
5. Plastic injection	

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